VOL. VI. JULY, 1933. NO. 3.

Journal

OF THE

Kansas Entomological Society

PUBLICATION COMMITTEE

PAUL B. LAWSON, Editor, Lawrence
ROGER C. SMITH, Manhattan R. H. PAINTER, Manhattan
W. KNAUS, McPherson DWIGHT ISELY, Fayetteville, Ark.

DR. FRANCIS HUNTINGTON SNOW
1840—1908

Entered as second-class matter December 31, 1927 at the Post-Office at McPherson, Kansas, under the Act of August 24, 1912

Kansas Entomological Society

Vol. VI, No. 3. July, 1933.

THE GENUS XESTOCEPHALUS (HOMOPTERA, CICADELLIDAE).

HAROLD T. PETERS, Lawrence, Kansas.*

The genus **Xestocephalus** is represented in North America by twelve species. Seven of these have previously been described. Five new species are described in this paper.

The characters which are used to separate species are chiefly the markings on the vertex and pronotum. In the case of those without markings on vertex and pronotum, the general color of the vertex and its shape are used. The markings of the elytra, while in general alike for some species, yet often show specific differences of definite value in separating species. The size of **robustus** and **trimaculatus**, as well as their markings, separates them from all other species. The external genitalia are of little or no specific value. The internal male genitalia are also of litte value except in the separation of **similis** from **pulicarius** in which instance the style shows constant characters for each species. The oedagus is of little practical value in classification.

Members of this genus seem to be taken for the most part in the southern and eastern states. **X. pulicarius** has been taken as far north as New York and Canada and **X. superbus** and **X. nigrifrons** are reported from Maine, but as a whole, the members of the genus occur most abundantly in the south.

KEY TO THE GENUS XESTOCEPHALUS IN NORTH AMERICA.

1. Vertex with distinct dots or lines 2
   Vertex without distinct dots or lines 8
2. Vertex and pronotum with numerous small dots; species large, 3.9 mm. .....**tessellatus** VanDuzee
   Vertex with linear markings 3
3. Females large, over 3.75 mm., and dark 4
   Females smaller, less than 3.75 mm. 5

* Contribution from Department of Entomology, University of Kansas.

4. Females very dark with hyaline spots on elytra, small, more brown than hyaline .... **robustus** sp. n.
   Females not so dark and hyaline spots on elytra very large, more hyaline than brown ..... **trimaculatus** sp. n.
5. Vertex black, distinct geminate lines ending in diverging lobes towards apex ..... **lunatus** sp. n.
   Vertex lighter and not so marked 6
6. Pronotum black with single white transverse band before posterior margin ..... **coronatus** Osborn & Ball
   Pronotum brown marked with spots 7
7. Entire median apical cell of elytra brown ..... **pulicarius** VanDuzee
   Only posterior part of median apical cell colored by brown tip of elytra ..... **similis** sp. n.
8. Large, 4 mm., piceous ..... **piceus** Osborn
   Less than 3.75 mm. 9
9. Uniformly rich brown with few hyaline markings near apex of elytra ..... **brunneus** VanDuzee
   Not uniformly brown 10
10. Mostly jet black species ..... **nigrifrons** Osborn
    Not black 11
11. Vertex broadly rounded, fulvous, immaculate .. **fulvifrons** sp. n.
    Vertex at least slightly angulate, light brown and often with faint markings ..... **superbus** (Provancher)

Xestocephalus robustus sp. n.
Fig. 5.

A large dark brown robust species, as large as **X. tessellatus.** Marked on vertex and pronotum much as in **X. pulicarius.** Elytra with a number of variously shaped hyaline spots. Length, female 3.9 mm.

Head narrower than pronotum. Vertex more than twice as wide as long, two-thirds longer at middle than next the eye, anterior margin evenly rounded, very broadly rounded with front. Pronotum almost one-half longer than vertex, two and one-half times as wide as long. Humeral margins slightly longer than lateral. Elytra distinctly exceeding abdomen.

Color: Vertex, pronotum and scutellum very dark

brown; elytra somewhat lighter. Vertex with light marks as follows: a circular spot at apex, a pair of lines along median line diverging near apex, running parallel to the front margin, forming a loop opposite the ocelli, and proceeding to the eye, a straight line connecting ocelli with the eye. Pronotum with four spots on anterior submargin, a spot in each lateral angle and a larger one mesad of this, and numerous smaller irregular spots on disk, posterior and humeral margins with thin subhyaline border. Scutellum dark with a pair of diverging oblong spots at base, and a spot on each lateral margin. Clavus with hyaline spots at end of claval veins and one on each margin near base, smaller faint spots scattered over surface. Corium covered with irregular hyaline spots, the larger hyaline areas lie along costal margin anterior to brown tip of corium and contain two rectangular or quadrate spots. Face dark brown with two crescentic lines on upper part enclosing a dark crescent and a semicircular spot on margin of genae beneath eye. Venter dark brown, legs slightly paler.

Genitalia: Female last ventral segment over twice as long as penultimate, posterior margin slightly concave to narrow median notch. Pygofer stout, bearing a number of rather stout dark spines; ovipositor slightly exceeding pygofer.

Holotype: Female, Ft. Pierce, Florida, Aug. 7, 1930. R. H. Beamer.

Type deposited in Snow Entomological Collection.

Xestocephalus trimaculatus sp. n.

Fig. 6.

As large as **X. tessellatus** but resembling **X. pulicarius** in markings. Elytra with many clear spots. Length, female 3.9 mm.

Head narrower than pronotum. Vertex nearly twice as wide as long, one-half longer at middle than next the eye, anterior margin rounded. Pronotum almost one-half longer than vertex, about two and one-half times as broad as long; lateral and humeral margins equal. Elytra strongly exceeding abdomen.

Color: Dark brown marked with fulvous. Vertex with a pair of L-shaped lines, one part parallel to median line and the other parallel to front margin; some pale marks between these and eye. Pronotum dark, marked with two small spots on anterior submargin, hind margin

and humeral angles with thin light border, numerous light spots on disk. Scutellum dark brown, apex lighter, two light spots on lateral margins. Clavus marked with small hyaline spots, one at base, one at end of each claval vein and two others next claval suture. Corium covered with irregular hyaline and yellowish spots, a very large one on costal margin containing quadrate brown spot. Apex of elytra brown including entire middle apical cell. Face brown. Venter dark brown, legs paler.

Genitalia: Female last ventral segment twice as long as penultimate; posterior margin with wide and shallow median notch. Pygofer rather short and stout bearing a number of long stout spines; the ovipositor slightly exceeding pygofer.

Holotype: Female, Beauregard Co., Louisiana, Aug. 16, 1928, A. M. James,

Type deposited in Snow Entomological Collection.

Xestocephalus lunatus sp. n.

A medium sized species resembling **X. pulicarius** but darker with more definite markings. Elytra with many clear spots. Length, female 2.8 mm.; male 2.3 mm.

Head slightly narrower than pronotum. Vertex about twice as wide as long in female, slightly longer in male, one-half longer at middle than next the eye, anterior margin rounded. Pronotum one-half longer than vertex, two and one-half times as wide as long; lateral and humeral margins subequal. Elytra greatly exceeding abdomen.

Color: Dark brown marked with fulvous. Vertex very dark brown marked with pale yellow as follows: a circular spot at apex, a line between ocellus and eye, a spot on inner margin of eye, a pair of lines each starting next the eye, extending along posterior margin of vertex, almost meeting at median line, then running parallel anteriorly well towards apex of the head and ending in diverging lobes. Pronotum dark brown with four spots on anterior submargin, lateral angles, two large spots on disk and two smaller ones between these and lateral markings, fulvous. Scutellum dark brown with pair of diverging oblong spots at anterior margin and apex lighter. Clavus marked with hyaline spots, the one at the base and the ones at the ends of the claval veins seem to be constant. Corium covered with irregular hyaline spots, an unusually large one on the costal margin just anterior to brown tip of elytra containing small quadrate spot. Face brown, with crescentic light line on upper

part, the tips of which are joined by another light line in females enclosing a dark crescent. Venter dark brown, legs slightly paler.

Genitalia: Male last ventral segment twice as long as penultimate. Valve barely visible. Plates broad at base tapering rather sharply to acute tip; covered with fine long silky hair and with a few spines on inner margin. Female last ventral segment more than twice as long as penultimate; posterior margin nearly straight with a slight median emargination. Pygofer rather short and stout bearing a number of long stout spines; the ovipositor slightly exceeding pygofer.

Holotype: Male, Plant City, Fla., Aug. 15, 1930, J. O. Nottingham. **Allotype:** Female, Yankeetown, Fla:, July 31, 1930, R. H. Beamer. **Paratypes:** Fourteen females from Sanford, Yankeetown, Fort Myers, Sebring, Fruitville, Plant City, all in Florida.

Types deposited in Snow Entomological Collection.

Xestocephalus similis sp. n.
Figs. 4, 4a, 4b.

A medium sized species resembling **X. pulicarius** but larger, paler and less distinctly marked. Elytra with many large clear spots. Length female 3.5 mm.; male 3 mm.

Head slightly narrower than pronotum. Vertex more than twice as wide as long in male, longer in female, one-half longer at middle than next eye, anterior margin rounded. Pronotum almost twice as long as vertex, more than twice as wide as long, lateral and humeral margins almost equal. Elytra greatly exceeding abdomen.

Color: Brown marked with fulvous. Vertex with faint markings similar to **X. pulicarius.** Pronotum marked with numerous indistinct spots. Scutellum with two spots at anterior margin and two on lateral margins fulvous. Elytra so covered with hyaline spots as to appear light marked with occasional brown spots and brown veins. Clavus with spots at ends of claval veins and irregular spots along claval suture. Corium covered with large hyaline spots, brown tip of elytra not including entire middle apical cell. Just anterior to this brown tip is a large hyaline spot on the costal margin containing a small quadrate spot. Face fulvous and unmarked in male; light brown and with two large spots on lorae in female. Venter brown, legs fulvous, generally darker in female.

External Genitalia: Male last ventral segment almost twice as long as penultimate. Valve barely visible. Plates broad at base tapering to acute tip; covered with long white silky hairs and with a few stout spines on inner margin. Female last ventral segment twice as long as penultimate. Posterior margin concave to slight median emargination. Pygofer rather short and stout bearing long stout spines; ovipositor slightly exceeding pygofer.

Internal Male Genitalia: Similar to **X. pulicarius** except that in the styles the basal angle of the slender portion is not so sharp. There is more of a hook-like projection on the inner end of the foot and the flat portion of the foot is concave, at least slightly so. The oedagus is similar to that of **X. pulicarius.**

Holotype: Male, Doniphan Co., Kansas, Aug. 20, 1924. R. H. Beamer. Allotype: Female, Douglas Co., Kansas, Aug. 31, 1930. Trap light, P. B. Lawson. **Paratypes:** Fifteen males from Douglas Co., Doniphan Co., and Leavenworth Co., Kansas. Eleven females from Douglas Co., Kansas.

Types deposited in Snow Entomological Collection.

This species has hitherto been confused with and included in **X. pulicarius.** It occurs along with that species in Kansas, but is definitely larger and lighter in color.

(Compare figures 2, 2a, and 2b with figures 4, 4a, and 4b).

Xestocephalus fulvifrons sp. n.
Fig. 1.

A narrow species with unmarked yellowish vertex and pronotum, elytra with many large clear spots. Length, female 2.8 mm.; male 2.6 mm.

Head slightly narrower than pronotum. Vertex two and one-half times as wide as long in male, one-third longer at middle than next the eye, anterior margin almost evenly rounded, very broadly rounded with front. Pronotum one-half longer than vertex, over twice as wide as long, humeral margin slightly longer than lateral. Elytra narrow, strongly exceeding abdomen.

Color: Vertex, pronotum and scutellum straw yellow except for dark brown basal angles of latter; sometimes darker markings showing through pronotum. Clavus with six hyaline spots; one just caudad of scutellum, two at ends of claval veins and three next claval suture, the apical two often coalescing forming a hyaline

band. Corium covered with large hyaline spots usually much coalesced; an unusually large hyaline spot on costal margin containing small quadrate brown spot just anterior to brown apex of elytra. Face of male pale brown, darker immediately beneath antennae; face of female darker brown with similar darker areas beneath antennae. Venter dark brown, hind margins of some segments sometimes pale. Legs lighter brown.

Genitalia: Male last ventral segment about twice as long as penultimate. Valve barely visible. Plates, viewed ventrally, rather broad at base tapering beyond middle to acute tips, covered with long fine white hairs and with a few spines on inner margin. Female last ventral segment twice as long penultimate; posterior margin nearly straight with a slight but definite median emargination. Pygofer stout, bearing a number of stout spines; ovipositor slightly exceeding pygofer.

Holotype: Male, Valentine, Texas, July 13, 1927. R. H. Beamer. **Allotype:** Female, same data. **Paratypes:** two males from Valentine, Texas and Holtville, California, and two females from Valentine, Texas and Holtville, California.

Types deposited in Snow Entomological Collection.

Explanation of Plate.

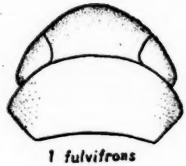
1. X. fulvifrons
2. X. pulicarius. 2a oedagus, 2b style
3. X. lunatus
4. X. similis. 4a oedagus, 4b style
5. X. robustus
6. X. trimaculatus

2b

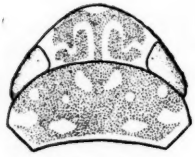
2a

4a

4b

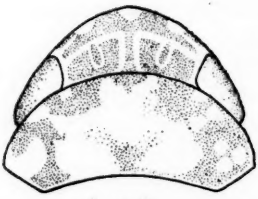


1 fulvifrons

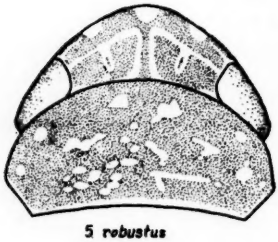


2 pulicarius

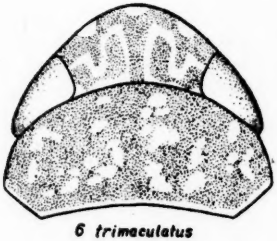
3 lunatus



4 similis



5 robustus



6 trimaculatus

THE AMOUNT OF SOIL BROUGHT BY INSECTS TO THE SURFACE OF A WATERED AND AN UNWATERED PLOT*

HARRY R. BRYSON **
Kansas Agricultural Experiment Station.

INTRODUCTION

For several years the writer has been interested in the amounts of soil brought to the surface by burrowing insects. The factors which influence their activities have also been of interest to the workers in the field of insect ecology.

The present paper embodies a discussion of data and observations obtained from a study of burrowing insects on two definite areas at Manhattan, Kansas, during four seasons—1927-1930, inclusive. An effort has been made to point out some activities of insects in relation to various environmental factors, with special reference to temperature and rainfall.

DISCUSSION OF REFERENCES

A brief review of the literature concerning the activities of burrowing insects in relation to their environment indicates that previous workers have not been particularly interested in the actual quantity of soil brought to the surface through the burrowing activities of insects. Studies of the burrowing activities as a general rule were confined to the observation of the habits of the insects and character of their burrows rather than to the researches in the amount of soil brought to the surface by them. Shaler (1891) found ants transferred annually enough material in a field near Cambridge, Massachusetts, to cover the surface of the soil with one-fifth inch of new soil. This is equal to about 30 tons per acre. Branner (1900) states that the mounds of various ants and termites of the tropics are of great size, numerous, and contain many tons of earth.

---

*Contribution No. 392 from the Department of Entomology.

**These studies were begun by the late Prof. J. W. McColloch in 1927, and continued by him until September, 1929. The writer wishes to express his appreciation to Professor Geo. A. Dean for his helpful suggestions in the preparation of this manuscript.

Shaler, N. S. The Origin and Nature of Soils.
1891 Twelfth Annual Rept., U. S. Geol. Survey, Pt. 1, pp. 213-245
Branner, J. C. Ants as Geological Agents in the Tropics.
1900 Jour. of Geology, 8:152

McColloch and Hayes (1922) called attention to the reciprocal relationship existing between insects and soil, and that soil is important as an environment for insect life. Bryson (1931) emphasized the fact that insects play no small part in the process of intermixing the soil when the various layers are fixed in their positions.

METHOD

On July 11, 1927, two rectangular, one-thousandth acre plots on loam soil were laid out adjacent to each other with 18-inch alleys surrounding them. These plots were cleared of vegetation and their surfaces leveled. Plot 31 was watered each evening with two and one-half gallons of water, except on days when appreciable rainfall occurred. This procedure served to keep the surface of this plot moist, except in the periods of excessive evaporation. Plot 32 was not watered, except by rainfall. Both plots have been kept free of vegetation, but the surface of the soil has not been disturbed since the experiment started.

Daily collections of soil brought to the surface by insects were started July 12, 1927, and continued as regularly as possible since that time. During 1928, collections were begun in February and continued until burrowing activities ceased in November. Soil samples were collected from June 1 until November 1 during 1929, and from April 1 to September 1 in 1930.

The collections were made each evening at 5:00 o'clock on days when showers or rains occurred, when the soil was collected before the rain to avoid losing the sample accumulated prior to the time of precipitation. The soil was collected by means of a small spatula and placed in one ounce tin boxes. Soil scattered some distance from the entrance to the burrow was carefully brushed into a small pile before being collected. Efforts were made not to include the dry surface soil when taking the samples. In some instances the excavated soil became so scattered by wind and the insects themselves that an accurate sample could not be obtained. No attempt was made to collect the soil on these occasions. Each month's accumulation was allowed to become air

McColloch, J. W. and Hayes, Wm. P. The Reciprocal Relation of Soil and Insects.
1922 Ecology, Vol. III, pp. 288-301.

Bryson, Harry R. Interchange of Soil and Subsoil by Burrowing Insects.
1931 Jour. Kans. Ent. Soc., IV. 17-24

dry in the office of the field insectary and was then weighed on the same date.

Beginning in July 1928, the burrows were counted and records made of the number of mounds of soil present on each plot. Observations were made regarding the identification of a few insects which were persistent in their efforts to establish burrows.

Rainfall records were taken by means of a standard rain gauge placed a few feet from the plots. Air temperatures were recorded by means of a hygrothermograph placed in the outer screen part of the field insectary. The records obtained from these instruments were checked with the college weather bureau records taken one-half mile away. Since the weather data taken at the field insectary checked very closely with those of the college, the latter were used in discussion of results.

PRESENTATION OF DATA

The data presented herein show that insects are influenced in their burrowing habits by the environmental factors present at the time the burrowing is done. The insects frequenting the two plots during the progress of these studies were those known to be attracted to areas devoid of vegetation. Since the two areas were kept free of plant growth, the visitants to the plots in many cases were insects which commonly frequent barren areas. This point is mentioned because the observations made by the writer indicate that some burrowing wasps and bees start their burrows near the bases of plants or foreign objects. A small plant will conceal both the mound of soil and the entrance to the burrow, thereby protecting the wasp and its young from their enemies. Soil near the roots of plants is shaded and remains moist, in which condition it is more readily excavated.

Observations show that the insects visiting the two plots belong chiefly to the order Hymenoptera, comprising different species with burrowing habits peculiar to themselves. Insects which required considerable time in which to construct a burrow, and those returning frequently to reprovision the burrow, established themselves upon the unwatered plot. This procedure was particularly true of ants and Bembecine wasps. Following a series of showers, distributed over a period of days, many individual species which ordinarily were attracted to the watered plot would frequent the unwatered one. During the hottest and the driest weather, more burrows

were excavated on plot 31 than on plot 32, but as a general rule the quantity of soil brought to the surface was much greater on plot 32.

Observations were made in February, 1928, in an effort to determine when the burrowing activities began. It was found that carabid larvae were the first insects to become active on these plots. These small larvae worked immediately beneath the surface and raised the soil, forming small meandering ridges of loose earth which formed the roofs of the tunnels. This soil was not brought from below but was a part of the first one-fourth inch of soil.

Table I gives the amounts of soil collected each month during the four seasons—1927 to 1930.

TABLE 1—SHOWING AMOUNT OF SOIL COLLECTED FROM 1927-1930, INCLUSIVE

	Plot 31—Watered Weight of soil in Grams			Plot 32—Unwatered Weight of Soil in Grams		
Month	Total	Daily Ave.	Number of Burrows	Total	Daily Ave.	Number of Burrows
			1927			
July (1)	98.89	4.94		29.61	1.48	
Aug.	128.61	4.15		195.41	6.30	
Sept.	128.04	4.27		99.35	3.31	
Oct.	30.89	0.99		7.69	0.25	
Nov. (1)	1.21	0.06		0.00	0.00	
			1928			
Feb.	5.61	0.20		0.42	0.01	
Mar.	6.65	0.21		2.91	0.09	
Apr.	0.75	0.02		0.00	0.00	
May	7.81	0.25		0.88	0.02	
June	22.09	0.74		28.44	0.94	
July	41.38	1.33		194.11	6.26	
Aug.	152.07	4.90	281	441.73	14.25	370
Sept.	33.62	1.12	61	211.07	7.03	101
Oct.	19.10	0.61	20	33.98	1.09	63
Nov.	0.44	0.01	1	12.09	0.40	14
			1929			
June	61.60	2.53	86	65.36	2.17	67
July	355.70	11.47	327	881.16	28.42	228
Aug.	233.47	7.53	284	256.91	8.29	121
Sept.	30.87	1.03	25	101.52	3.38	37
Oct.	00.00	0.00	00	38.52	1.24	8

(1) 20 days only.

(Table I Continued on Next Page)

(Table 1 Continued from Preceding Page)

1930

Apr.	19.31	0.64	36	98.85	3.29	91
May	95.82	3.09	200	225.18	7.26	201
June	135.96	4.53	184	202.24	6.74	240
July	232.45	7.49	219	562.80	18.60	143
Aug.	280.00	9.03	102	139.12 (2	4.49	62
Total	2122.34			3829.35		

(2) Incomplete, no records Aug. 9-23.

4 Seasons

An examination of Table I reveals the fact that burrowing activities, as indicated by the amount of soil brought to the surface each month, were much greater in 1929 and 1930 than during the seasons of 1927 and 1928. The average amounts of soil brought to the surface during June, July, and August were much greater in 1929 than the amounts excavated daily for the same months for the other three seasons.

TABLE II—SUMMARY OF THE AMOUNTS OF SOIL BROUGHT TO THE SURFACE BY MONTHS FOR THE FOUR SEASONS.

Month and Year	Total	Daily Ave.	Burrows	Total	Daily Ave.	Burrows
February 1928	5.61	0.20	—	0.42	0.01	—
March 1928	6.65	0.21	—	2.91	0.09	—
April 1928-30	19.06	0.32	36	3.29	0.55	91
May 1928-30	103.63	1.67	200	226.06	3.65	201
June 1928-30	219.65	2.44	270	296.04	4.93	317
July 1927-30	728.42	6.44	545	1667.68	13.45	371
August 1927-30	794.15	6.40	567	1033.17	8.33	553
Sept. 1927-29	192.53	2.03	86	411.94	4.57	138
Oct. 1927-1929	49.99	0.54	20	41.67	0.45	71
Nov. (3) 1927-28	1.61	0.32	—	12.09	0.24	—

(3) 50 days.

An examination of Table II shows that a slight increase in activity occurred on both plots on March and April over that shown in February. Not until May did the burrowing activity increase to a significant degree when the average amount of soil brought to the surface daily was 1.67 grams on the watered plot which compared with a daily average of 3.65 grams on the unwatered one. The numerical data showing the amount in grams are not significant except in so far as they show the relative amount of insect activity in progress on the two plots.

Counts of the number of burrows made on the two plots in April, 1930, show a total of 36 burrows on plot 31, while 91 burrows were excavated on plot 32. The number of burrows occurring on each plot is a more accurate criterion to the intensity of insect activity than are the amounts of soil excavated, since it usually indicates that various individuals are visiting the plots. One species of insect may be responsible for a large amount of excavated soil, while other visitants contribute relatively a very small amount.

A count of the burrows on each of the two plots in May of the same year indicates that the activity was approximately the same on both the watered and unwatered plots, with 200 burrows on plot 31 and 201 on plot 32. Observations indicate that the condition of the surfaces of the two plots is more nearly the same during May than at any other time of the year. This is due to the fact that high evaporation did not take place during this month in 1930 and the rainfall tended to keep moist the surface of the unwatered plot.

Data recorded for June, 1928 and 1930, show a great increase in activity on the unwatered plot, for there were approximately one and one-half times as much soil brought to the surface on plot 32 as was excavated during the month of May. On plot 31 there was more than twice the amount of soil brought up in June as compared with the amount collected in May. There were two ant hills on plot 32 which contributed to the amount of soil excavated daily. It may also be seen that there was an increase in activity on both plots for the month of June over that evidenced in May.

Since July and August were the months which showed the greatest activity, they were given more attention in comparing the data collected during four seasons.

The number of burrows on plot 31 was much greater in both July and August than on plot 32. This fact indicated that during these months, when the temperatures were high, a greater number of insects were attracted to the cooler or watered plot. The larger amount of soil brought to the surface on plot 32 can be attributed to the excess burrowing of **Berrex americana** and the ants which had become established on the plot earlier in the season.

The first heavy rain which fell after the collections were begun July 12, 1927, occurred on July 20. During the period from July 12 to 20 there occurred two small showers, one on July 13 and the other on July 17, each of which amounted to slightly less than one-half inch. Following each of these showers as the daily maximum temperatures increased, there was a decided increase in the amount of soil excavated on plot 31, while very little activity occurred on plot 32.

Following a one and one-half inch rain, a sudden increase in burrowing occurred on both plots. This rain was followed by several smaller showers two or three days apart, which tended to retard the amount of burrowing done. Burrowing activities were gradually renewed toward the end of the month as the maximum temperatures increased, with greater accumulations of soil on the watered plot than on the unwatered one. During the month of August a larger quantity of soil was brought to the surface on the unwatered plot than on the watered one due to the fact that the rains were so frequent and heavy that the surface of the watered plot remained too wet for burrowng to take place.

On July 20, when the minimum temperature dropped to 50 degrees and the maximum for the same day to 81 degrees, the amount of activity was checked suddenly and there was more soil brought to the surface of the unwatered plot than to that of the watered one. There was a marked increase in the amount of burrowing accomplished a day or two following a rain, provided the temperature did not drop too suddenly. Following these periods of inactivity, occasioned by unfavorable weather, activity was gradually resumed as the temperature increased.

As the temperature raised during the day, the amount of burrowing done increased until the peak was reached in the late afternoon after which there was a

general decrease until sundown, when there was complete cessation. During the extremely hot, dry weather, when the maximum daily temperatures approached 105 degrees in the afternoon, many of the insects burrowed during the forenoon.

The last rain in August, 1927, was on the 28th, after which there was a gradual increase in daily minimum temperatures from 72 degrees two days prior to the rain, to 85 degrees two days afterwards. Following this rain, a sudden increase in activity took place on August 29, after which there was a rapid decline.

Operations were continued from June through July with a slight increase in activity during the first four days of July as the maximum temperatures ascended, but decreased when the temperature fell one day prior to the rain. It may be stated here that sunlight stimulates activity while cloudy weather discourages it. However, it appears that these soil insects have work to do and if they are detained for a period by continuous wet, cold, extremely hot, or otherwise unfavorable weather, they begin to work with renewed energy after having been so checked.

A heavy rain fell during the month in addition to numerous showers which tended to discourage burrowing activities on the watered plot. As a result, the soil brought to the surface of the unwatered plot exceeded by far the amount excavated on the watered one.

In August of the same year, there were two rains, each amounting to more than one inch at the beginning of the month, followed by a 12-day period, free from precipitation, except for two small showers. Apparently this period was an ideal one for burrowing activities to take place. Following the rains during this month, there was an increase in burrowing in every case.

In a number of instances, the temperatures began to ascend, following rains, and, coincident with this rise was a corresponding increase in burrowing activity on both plots. On August 24, when the minimum temperature dropped to 46 and the maximum remained at 95, there was an increase in burrowing on the unwatered plot, while there was a slight decrease in activity on the watered one.

The following day, when the minimum temperature was 48 degrees and the maximum dropped to 80 degrees, there was a cessation of burrowing on the watered plot.

The following day, August 26, when the maximum temperature reached 94 degrees, there was a sudden increase in the amount of burrowing on both plots, even though the minimum temperature remained at 48 degrees.

The amount of activity fluctuated with the rainfall and with the variations in the daily maximum temperatures. There was a decided increase in the amount of burrowing accomplished during July, 1929. The amount of burrowing increased from the beginning of the month until July 26, when the peak of the activity was reached.

There was a period in the month extending from July 12 until July 30, during which there was an entire absence of rainfall. The maximum and minimum temperatures for this period were similar to those of the same month in 1928, the daily fluctuations in the amount of activity on both plots were found to be largely due to the peculiar habits of the insects involved.

It was interesting to note the regularity in the amounts of soil brought up daily on each plot. The rains during this month that fell July 10 and 11, checked insect operations entirely.

Continuing the study into August of this same year, there were six days during the month when the maximum temperatures dropped to 82 degrees F. or below. These periods were marked by sudden retardation of insect activities. There were five days with a maximum temperature above one hundred. Apparently these periods favor burrowing if the periods follow immediately after successive days when the maximum temperatures fail to go above 85 degrees F.

The month of July, 1930, was characterized by having no periods of precipitation which would affect the burrowing activities of the insects. There were 18 days in which the maximum temperature reached 100 degrees or more, the highest being 109 degrees on July 27. The largest amount of soil secured in a single day, during these studies, was collected on July 19, when 130 grams were brought to the surface on plot 32. The amounts of soil collected daily on plot 31 fluctuated with the rise and fall in daily maximum temperatures and were fairly uniform.

On July 27, when the temperature reached 109 degrees, insect activities on both plots practically ceased,

but when the daily temperatures dropped to 100 degrees on succeeding days, there was an increase in the number of burrows and amount of soil brought to the surface.

August, 1930, was marked by extremely hot weather the first ten days in the month, with a very rainy period from the 11th to the 16th. During this period of precipitation, no records were taken. The first nine days the maximum daily temperatures never dropped below 100 degrees, the highest temperature being 113 degrees, when all burrowing activities ceased.

Following this extremely hot day, burrowing, though greater on the watered plot, gradually increased on both plots until August 7, when a perceptible decline took place prior to the rain on August 11. During the last five days of this month there was decline in burrowing activities. As a general rule, the amount of burrowing rapidly declined toward the last of August with very little activity in evidence during the month of September.

The burrowing on the two plots gradually decreased until November 20, after which no burrows were made. The record for November is based upon observations of a single year.

SUMMARY

1. A study of burrowing insects during four seasons —1927 to 1930, inclusive—upon a watered and on an unwatered plot, showed that their activities were influenced greatly by the environmental factors present at the time the burrowing was done.

2. The period of greatest activity each year was found to extend from July 15 to August 16 on both the watered and unwatered plots.

3. Observations indicated that burrowing activities were greatest on the watered plot when the air temperatures were highest and on the unwatered one when air temperaturs were lowest.

4. There was a sudden increase in burrowing activities on both plots following a period of unfavorable weather. Regular rains followed by temperatures ranging from 90 degrees to 100 degrees F. stimulated burrowing. Burrowing ceased materially when the maximum daily temperatures fell below 80 degrees F. or approached 113 degrees F.

TWO NEW SPECIES OF VESPOIDEA (HYMENOPTERA), WITH NOTES ON A PREVIOUSLY NAMED SPECIES

RAYMOND ROBERTS
University of Nebraska, Lincoln.

In the taxonomic work of the writer on the vespoid wasps a number of previously undescribed species have been encountered. This paper includes two new species, with rearing notes on one of them. The system of Allen and Jaynes (**Proc. U. S. Nat. Mus.**, LXXVI, Art. 17, p. 1-105; 1930), with regard to terminology and characters used, has been employed in the description of the following species of **Tiphia**, with the idea of maintaining a standard of characters for this group. The types and paratypes of these species are in the collection of the Department of Entomology of the University of Nebraska, except in the one instance mentioned later. The writer wishes to acknowledge the assistance of Prof. Myron H. Swenk in the preparation of this paper.

Tiphia diminuta n. sp.

Male. Length 5 - 7mm. Punctures on the front of first-degree density, smaller on the lower front, with minute interspaced secondary punctures from lower eye orbits to antennal fossae. A prominent carina extends from the lower front upward for a short distance, broadening into a depressed impunctate space which extends upward to the ocelli to form the impunctate preocellar region. Vertex with scattered punctures in the ocellar region; a patch arising in the densely punctate region of the lateral front, extending up on each side between the ocelli, mainly of second-degree density, these punctures extending into the ocellar triangle. The punctures of the front continue on the vertex laterally along the eye margin, bipunctate on the vertex, with the punctures of the occipital area shallow. Clypeus deeply emarginate, the emargination at least one-half as deep as wide, the apical points prominent; an impunctate clypeal border which is equal to two-fifths, with an extension equal to three-fourths of the clypeo-antennal distance, the puncturation elsewhere consisting of small, regular, evenly spaced primary punctures of second-degree density, with a few minute secondary punctures. Antennocular distance slightly greater than the width

Published with the approval of the director as Paper No. 130, Journal Series, Nebraska Agricultural Experiment Station.

of the antennal fossa. Pronotum with a complete, prominent dorsal carina, the puncturation irregular, mostly of third-degree density, slightly more dense laterally, secondary punctures lacking. Dorsal carina of the pronotum extending ventro-caudad on the pleural surface, merging into the coarser striae on the lower half of pleura, the entire pleural surface striate, the striae much coarser on the lower half, median groove absent, the pleura bearing also a few large shallow punctures. Mesepisternum smooth, with small, round primary punctures of third-degree density, a few secondary punctures, the punctures more dense on the upper portion. A distinct premarginal groove on the posterior slope of the mesepisternum which extends up to the spiracle. Scutellum and metanotum moderately punctured, the punctures of uniform size. Legs varying in color from black in some cases to reddish in others, major calcarium of hind tibia tapering uniformly from its base to apex. Tegulae reddish, smooth, semitransparent, as wide as long. Wings clear hyaline, veins and stigma reddish, the apical extension of the radial cell equal to that of the second cubital cell. Lateral carinae of the propodeal areola straight, usually well marked for their entire length, the areola usually three-fifths as wide at base as it is long, keystone-shaped to parallel-sided. Median carina of the areola usually reaching two-thirds of the distance to the apex, but sometimes entirely absent. Areola, as well as entire dorsal surface of the propodeum, reticulate with a number of large carinae running to the posterior dorsal ridge. Entire sculpturing of the propodeum quite variable, apparently depending upon the size of the individual. No more than a trace of a median carina on the lower part of the posterior face of the propodeum, this area densely striate and bearing shallow setigerous punctures. A preapical band of primary punctures crosses the first tergite and extends forward laterally. Otherwise the primary punctures are well distributed over the tergite, small and sparse, the secondary punctures scattered, minute. The remaining tergites, for the most part, uniformly punctured with sometimes a reticulate, impunctate band of varying width across the tergites. Well distributed punctures of third-degree density on the tergites, with a few scattered secondary punctures, the punctures more numerous on the basal portion, comparable in size to the primary punctures on the remainder of the body. First sternite practically smooth on disk, rugose towards base, bearing

a few large scattered punctures, the lateral grooves less than half the length of the segment. The remaining sternites, except the second and basal bands of reticulation on the succeeding ones, moderately densely punctured, the punctures increasing in size from the base to apex of sternites. Second sternite sparsely uniformly punctured. The bands of reticulation on sternites three to six wider than the bands of the corresponding tergites, finely reticulate, the reticulation gradually giving way to small sparse punctures. A prominent tooth on the lateral disk of the fifth sternite, on each side, with or without an impunctate band extending across the sternite between the teeth.

Female. Length 4.5 - 7 mm. Front minutely punctured with setigerous punctures, and reticulate on an area on its sides that is four-sevenths as broad as the antennocular distance, narrowed by approximately two puncture rows above and between the antennae, the lower primary punctures small. Punctures on the disk of the front mostly of third-degree density, almost lacking on the upper one-third, the area faintly shagreened in places. A number of punctures of first or second degree density in the ocellar triangle, otherwise the punctures on the vertex, like those on the upper front, are sparse and irregular, usually in rows of from two to five, mostly uniform round small punctures of second-degree density, but with an occasional irregular large one on some specimens. The shagreening of the head usually more regular on the vertex behind the ocelli. Clypeus with its lateral margins slightly convex, the extension broad, impunctate, barely emarginate, the basal punctures small. Clypeal extension, palpi, antennae, and mandibles red. Pronotum without a well defined dorsal ridge but with well developed lateral prolongations of this ridge. The primary punctures of the pronotum few but large, usually of first-degree density in the center, otherwise of third-degree density and bearing a few minute interspaced secondary punctures, the punctures with a dimpled edge posteriorly. An area on the lateral disks of the pronotum almost impunctate, with a tendency for an extension of this area in a band across the middle of the punctate area, the width of the impunctate apical border variable, usually of greater medio-longitudinal extension than the punctate area. Propleura finely striate on the entire surface behind the extension of the dorsal ridge, with a row of shallow pit-

like punctures along the upper edge of this ridge. Mesepisternum very sparsely bipunctate, reticulate on disk, and bearing a premarginal groove along the posterior edge, as in the males. Scutum with the notauli and the anterior medial groove continuous. Disk of scutellum impunctate, with a row of punctures of large size around the posterior border, interspaced with a number of punctures about half as large as the primary punctures, a few of the secondary punctures on the lateral and anterior borders, altogether with not over four to six primary punctures and ten to twelve secondary punctures, with a number of scattered secondary punctures of microscopic size. The punctures of the metanotum uniform in size and about the size of the larger secondary punctures of the scutellum, the punctures sparse, the surface inclined to be shagreened. A trace of a median longitudinal groove on the scutellum, the groove more prominent on the metanotum. Hind basitarsus bearing a deep, conspicuous groove on the posterior surface, half as long as the entire segment, the segment bearing a series of lanceolate spines, varying in number, on the outer surface, the longest one being apical. Major calcarium of hind tibia tapering to apex. All tibiae and tarsi light, the remainder of the legs deep red. Wings clear hyaline, the nervures yellowish, the stigma red. Tegulae semitransparent, red, as broad as long. Propodeal areola keystone-shaped, two and one-half times as long as its basal width, lateral carinae not prominent, the median carina variable, usually reaching from the base half way to the apex. The entire dorsal surface of the propodeum finely reticulate, the posterior dorsal ridge well defined. Entire lateral surface of the propodeum finely striate, coarser above. Posterior surface finely punctured with setigerous punctures, the median carina not developed. Small round punctures well distributed over the first tergite, more numerous on the sides and a band before the apex, with a rather broad impunctate preapical band. The first tergite slightly shagreened on disk, the remaining tergites conspicuously shagreened. Punctures of tergites two to six mostly of uniform size and scattered well over the tergites, the punctures increasing in density towards the apex of the abdomen. The punctures are usually in two fairly well differentiated bands across the tergites, the first of these bands mostly concentrated just anterior to a line drawn across the center of the tergite, the posterior band usually concentrated upon about the center of the

apical third of the tergite, the punctures of this band tending to develop into deep pit-like punctures which run together on the fourth and fifth tergites. Each tergite bears a terminal row of shallow vestigial punctures. Disk of first sternite finely punctured with setigerous punctures, the lateral grooves running to the margin three-fourths of the distance from the apex of the segment. Hypopygium very coarsely shagreened and shallowly punctate. Pygidium impunctate on the apical three-fourths, faintly shagreened, the impunctate area reddish, the punctate area dark, a central impunctate emargination of the punctate base.

Holotype: Glen, Sioux County, Nebraska, August 20, 1906 (H. S. Smith) female.

Allotype: Monroe Canyon, Sioux County, Nebraska, August 20, 1908 (R. W. Dawson) male.

Paratypes: Glen, Sioux County, Nebraska, August 17 - 21, 1906 (H. S. Smith), 6 females; (P. R. Jones), 4 females; Harrison, Sioux County, Nebraska, August 20, 1912 (R. W. Dawson), 11 females; August 3, 1913 (L. T. Williams), 1 female; Monroe Canyon, Sioux County, Nebraska, August 12, 1908 (C. H. Gable), 1 male; August 17, 1908 (R. W. Dawson), 7 males; August 13, 1912 (R. W. Dawson), 5 males; Auburn, California, October 20, 1918 (L. Bruner), 2 females.

There seems to be a great deal of variation in the actual extent and density, as well as the size of the punctures, on all of the specimens of this species, both males and females, so that definite statements are difficult for these characters. However, the relative density and size of punctures is fairly constant; i. e., in a specimen with small sparse head punctures the punctures will be proportionately small and sparse on the other parts. In the male there seems to be a definite correlation between size of individual and size and density of punctures, but this does not hold true in the female. An area on the male which seems to be quite constant, and might prove to be diagnostic in the female as well as in the male, is the first sternite, which is, however, rather hard to define. The lateral grooves on this area on the male may vary in length on the two sides of the same insect. The teeth on the fifth sternite of the male, together with the deeply emarginate clypeus, with a broad impunctate border, and the relative amount of puncturation on the various parts, are the characters which identify it.

This species is the smallest known to the writer in

the female, and can be identified by the presence of the basitarsal groove and the shape of the basitarsal spines, and the general light color of its appendages.

Two female specimens collected by L. Bruner at Auburn, California, apparently have no diagnostic differences from the Nebraska series of this species. They do have the appendages darker as a rule, except the tegulae, than the Nebraska material, and have a few punctures on the disks of the lateral surfaces of the prothorax, which is not true of the Nebraska material, while the lower part of the lateral surfaces of the prothorax is more coarsely striate than the rest, which also is not true of the Nebraska specimens.

Sapyga minor n. sp.

Male. Length 7 mm. Black. A minute spot on each side of clypeus, a broad V-shaped mark near apex of front (between the antennae), the emarginations of the eyes, a narrow stripe behind the eyes, a narrow, widely interrupted collar on anterior edge of pronotum and a dot on each posterior angle, a small spot on the propodeum, and small spots on the lateral posterior edges of all of the abdominal segments with the exception of the third, white. A transverse frontal ridge not bearing a median longitudinal ridge to the clypeus. Constricted area of the front below the frontal ridge short, with two irregular transverse rows of punctures. Antennae rufous beneath, dark above. Legs all black. Wings hyaline, nervures black.

Holotype: Mitchell, Scottsbluff County, Nebraska, male.

Paratype: Boulder County, Colorado, August, 1926. emerged in laboratory. January 20, 1927 (C. H. Hicks) male. The paratype is in the private collection of the collector.

The paratype is slightly smaller than the holotype (6 mm.) which may be explained in the following note attached to the specimen, "Larva of a bee, the body on which this wasp fed did not eat all food hence this wasp may be small". It also differs from the holotype in being much less marked with white, having only a very small spot on each side of the frontal attachment to the clypeus, the emarginations of the eyes, an obscure spot behind the eyes and another on the shoulders, white. Apparently there is much variation in the extent of the markings.

The following note also accompanies the paratype:

"Reared from cell of what appears to have been an **Osmia** bee—taken from stump at base line".

Sapyga minor is the smallest species of Sapygidae described from North America. It differs from **Sapyga aculeata** Cresson, mainly in size, being only about half as large as that species, but also in the extent of the white markings. It is easily distinguished from all other species of **Sapyga** by its obviously black color.

Eusapyga rubripes Cresson.

E. T. Cresson presented a key before the Academy of Natural Sciences of Philadelphia in 1880, for the separation of twenty-one species of Sapygidae in the genera **Eusapyga** and **Sapyga,** eighteen of which were new. A statement was appended to the key to the effect that detailed descriptions of the new species would be published shortly. The wide interests of Mr. Cresson in the Hymenoptera prevented his ever returning to this task.

During the progress of the taxonomic studies by the writer a number of specimens were identified as **Eusapyga rubripes** Cresson, and to check the accuracy of this identification specimens were sent to the Academy of Natural Sciences where they were compared with the type by Mr. E. T. Cresson Jr:, and the identification verified. A short description of this species follows:

Female. Length 10 - 13 mm. Black. Mandibles black, first two antennal segments red, black beyond. Markings pale yellowish, varying somewhat in arrangement, but usually composed of an inverted T on the front between the antennae, the inner and outer orbits of the eyes, broken by a space over the eyes, a spot on the vertex on each side, an anterior and posterior prothoracic collar, both usually interrupted in the center, the anterior one always so, a large spot on mesopleura, large spots on the scutellum obviously divided into a minor spot on the anterior lateral lobes of the scutellum and large spots on the scutellum proper, lateral spots on the postscutellum and propodeum, complete dorsal bands on each abdominal tergite, with the exception of the third and last, that on the third interrupted, the last with lateral spots, and lateral spots on sternites two to five. Clypeus broadly joined to the front, front elevated, antennae inserted beneath this elevation and in front of the eyes.

Homotype: Glen, Sioux County, Nebraska, August 20, 1906 (L. Bruner), 1 female. Other specimens from the some locality are August 14 (L. Bruner), 1 female; August 15, 1906 (P. R. Jones), 1 female, at hole of **Anthidium** sp. 2 females: August 20, 1906 (H. S. Smith), 1 female, on Cleome; and August 13, 1906 (H. S. Smith), 1 female.

RELATIVE IMPORTANCE OF SPECIES OF GRASSHOPPERS IN NORTHWESTERN ARKANSAS [1]

William R. Horsfall, Allen W. Dowell, and Charles E. Palm [2]
University of Arkansas

Grasshoppers are not usually considered among the more important insect pests of Arkansas. They may cause local injury during some years, but this injury is never extensive. Their lack of importance here, when compared with their importance in the states of the plains, is probably due to the relatively small area of farm land devoted to perennial legumes and grasses.

The purposes of this study were to determine the common species of grasshoppers occurring in northwestern Arkansas and the economic importance of these species. To secure this information, collections of grasshoppers were made at intervals of about two weeks throughout four summers (1927, 1928, 1929, and 1931), in locations which were taken as types of habitats in which grasshoppers were abundant. All of these collections were made in Washington County, Arkansas. These records were supplemented by miscellaneous collections made in other locations when time permitted, and by collection notes and records accumulated by the Department of Ento-

1 Research Paper No. 292, Journal Series, University of Arkansas.

2 This study was carried on by the authors successively while working as student assistants for the Department of Entomology at the University of Arkansas. The records were made by the first author in 1927 and the earlier part of 1928, by the second in the latter part of 1928 and throughout 1929, and by the third author in 1931. This study was undertaken as an incident to other work and was carried on largely in spare time, and hence lacks completeness and definiteness in many particulars.

The writers are indebted to Mr. Dwight Isely of the Department of Entomology for suggestions and assistance throughout the course of this study. They are also indebted to Mr. A. N. Caudell, of the U. S. Bureau of Entomology, for the determination of doubtful species.

mology. A number of regional lists of grasshoppers from the South, like those of McNeill (3), (4), have been published, but in these attention was given to taxonomy and distribution rather than to the economic importance of the species concerned.

The weather during the four years in which collections were made represented all extremes. During the summers of 1927 and 1928 there was above the average rainfall for this region. The summer of 1929 was relatively dry with severe drought extending throughout August and September. During the year of extreme drought, 1930, no collections were made. In 1931 the rainfall was somewhat below normal, but since this year followed two years with very dry summers it was a year of unusual grasshopper abundance.

List of Species Collected

The following is a list of the species collected.

Syrbula admirabilis Uhler, **Dichromorpha viridis** Scud., **Orphulella speciosa** Scud.

Arphia xanthoptera Burmeister, **Chortophaga viridifasciata** De Geer, **Hippiscus rugosus** Scud. (5), **Dissosteira carolina** L., **Spharagemon aequale** Say (5), **Spharagemon bolli** Scud. (5), **Mestobregma kiowa** var. **thomasi** Caudell. (5)

Schistocerca americana Drury, **S. obscura** Fab. (5), **S. damnifica** var. **calidor** R. & H. (5), **Camplacantha olivacea** Scud., **Melanoplus differentialis** Thomas, **M. mexicanus** Riley, **M. femur-rubrum** De G., **M. bispinosus** Scud. (5), **M. bivitattus** Say, **M. keeleri** Thomas (5), **M, ponderosus** var. **viola** Thomas (5), **M. scudderi** Uhler (5), **M. packardi** Scud. (5)

McNeill (6) reported the occurrence of 27 species of Tryxalinae and Melanopli in northwestern Arkansas. The area covered in his collections included most of the counties of the northwestern part of the state, and doubtless a greater effort was made to collect rare species. Those species not included in our list but recorded by McNeill are as follows: **Tryxalis brevicornis** L., **Erritettix virgatus** Scud., **Chloealtis conspersa** Harris, **Orphulel-**

3 McNeill, Jerome. 1899. Notes on Arkansas Tryxalinae, Can., Ent., 31: 53-55.

4 McNeill, Jerome. 1899. Arkansas Melanopli. Psyche 8: 332-334, 343-346, 366-371.

5 Determined by Caudell.

6 Loc. cit.

la pelidna Burm., **O. decora** McNeill, **Boopedon auriventris** McNeill, **Hesperotettix pratensis** Scud., **Dendrotettix quercus** Riley, **Paratylotropidia brunneri** Scud., **Melanoplus impiger** Scud., **M. impudicus** Scud., **M. obovatipennis** Blatchley. **M. gracilis** Brunner, **M. sylvaticus** McNeill, **M. baconi** McNeill, **Phoetaliotes nebrascensis** Brunner.

Habitats Studied and Dominant Species

The perennial legumes, clover and alfalfa, are occasionally injured by grasshoppers and are a source of infestations occurring late in the season to nearby cultivated row crops. The clover and alfalfa fields swept for grasshoppers were located on the Agricultural Experiment Station Farm north of Fayetteville. The dominant species taken in this habitat was **M. femur-rubrum.** In 1931 approximately 90 per cent of all adult specimens collected on clover and alfalfa were of this species. In 1927 this species made up 50 per cent of the collections, and in 1928, 80 per cent. **M. differentialis** was apparently next in importance but tended to migrate to taller crops as the nymphs approached maturity. In 1931 this species was probably as important on alfalfa as **M. femur-rubrum.** Early in summer **Chortophaga viridifasciata** was most numerous.

Regular collections were also made from row crops grown on the Experiment Station Farm. In the tall grasses, corn, the various types of sorghum, and Sudan grass, **M. differentialis, Schistocerca americana,** and **S. obscura** were the more important species. **M. femur-rubrum** was probably as numerous as any of the other species, but because of its smaller size was rated as of less importance. The grasshopper population in soybeans was a composite of those species found in the tall grasses and in the perennial legumes.

Much of the pasture area of northwestern Arkansas is in the uplands, where the soil is very dry during the summer. The pasture plants are largely native grasses and sometimes include Lespedeza. One location where collections were made throughout the four years was a typical hill pasture, free from woodland. The grasshopper fauna in this type of location was divided more evenly among a large number of species than in cultivated fields. In the early summer **Chortophaga viridifasciata** was the most abundant species. In late summer and fall **M. bispinosus** was consistently most numerous and sometimes distinctly a dominant species. The other species

of numerical importance in this habitat were: **M. femur-rubrum, M. mexicanus, Orphulella speciosa, Hippiscus rugosus,** and **Syrbula admirabilis.** Of these species, **H. rugosus** was most consistent in occurrence and was associated with **M. bispinosus** in other habitats.

Upland pastures partly overgrown with woods are also common in northwestern Arkansas and present another type of habitat. Collections were made from such a location in 1928, 1929, and 1931. This pasture was located on a cherty hillside, which was overgrown with wild grasses and scattered trees and shrubs. In late summer the grasshopper fauna in this habitat is dominated by three species of Melanoplus—**M. scudderi, M. keeleri,** and **M. ponderosa**—and **Spharagemon bolli;** in late fall **Arphia xanthoptera** becomes the most abundant species.

Discussion of Species

The red-legged locust **(M. femur-rubrum)** is probably the most numerous species in northwestern Arkansas. It was taken from every habitat in which collections were made, except woodlands. In meadows of clover or alfalfa, it made up 50 to 90 per cent of the grasshopper population. It was also the most abundant species during the latter part of the season in low-lying grassland and was numerous in upland pastures. In row crops the species is abundant but yields in importance to some of the larger species.

The lesser migratory locust **(M. mexicanus),** which may be the most important of the small species of Melanoplus in the Great Plains, was not taken in large enough numbers to be of importance in Arkansas. This species was most numerous in upland pastures, ranking there about with **M. femur-rubrum,** but in this habitat both of these species were much less important than **M. bispinosus.**

The blue-legged locust **(M. bispinosus)** is the dominant species in the dry upland pastures. In such situations it is usually more numerous than any other species. It is also the dominant species where Bermuda grass is grown in lowlands. **M. bispinosus** is not usually included as an important species in the literature of economic entomology, but in Arkansas it ranks next to **M. femur-rubrum** among the smaller grasshoppers.

The yellow locust **(M. differentialis)** may be the

most important grasshopper from an economic standpoint in northwestern Arkansas. Its importance is due in part to its large size as well as numbers, and in part to concentration on certain crops and in certain seasons. Injury by the adults is particularly conspicuous on corn, and by the nymphs on alfalfa. When compared with **M. femur-rubrum,** the species is restricted in its breeding range. Nymphs may be found in large numbers in any season in clumps of Johnson grass and in fields of Sudan. They seem to require tall cover and are seldom found in short grasses. Their variation in numbers from year to year is also great. This species was most important in 1931, the only year of the four when grasshoppers were particularly destructive.

M. scudderi, M. keeleri, and **M. ponderosus** are associated together in half-wooded pastures. The habitat in which they feed naturally has a poor growth of grass, and they doubtless reduce the sparse forage still more. None of these are usually regarded as of economic importance. **M. ponderosus** was always found in the shade of trees, while **M. keeleri** tended to seek the sunny spots. **M. scudderi** did not seem to show any preference in this regard.

M. bivitattus, one of the most destructive grasshoppers in the United States, is of rare occurrence in northwestern Arkansas.

The American bird locust, **Schistocerca americana,** is of importance locally, and under favorable conditions it may be the dominant species. An essential requirement in its environment is apparently the presence of tall grass for cover for both nymphs and adults. It is more dependent upon tall grasses than is any other species occurring in this region. It is most abundant in fields of Sudan grass, Johnson grass, and bluestem (**Andropogon furcatus**). In August, 1931, the adults were very abundant in corn, occurring in about the same numbers as **M. differentialis.**

The green bird locust, **S. obscura,** is not usually listed among economic species of grasshoppers. Nevertheless, it is destructive locally in Arkansas and is perhaps fully as important as **S. americana.** Its breeding habits are similar to those of **S. americana,** but it prefers more succulent food, seldom being found in the drier grasses like Andropogon. It is less restricted, however, in its choice of cultivated crops. Like the yellow locust, its nymphs tend to congregate in clumps of tall grasses, such

as Johnson grass, and to move from these to cultivated crops. They also feed in large numbers on cowpeas and soybeans and occasionally on cotton. The nymphs are gregarious and as many as 50 or more may be found feeding on a single plant.

The northern green striped locust (**Chortophaga viridifasciata**) was the most widely collected species. It occurred in all habitats where general collections were made, even with more regularity than the red-legged locust, and approached the latter species in numbers, especially in meadows and pastures. It appeared in greatest numbers early in the summer, before adults of most other species matured.

The other species of the Oedipodinae were not attracted in appreciable numbers to cultivated fields. **Arphia xanthoptera** was quite numerous and conspicuous in partly wooded pastures late in the season. **Hippiscus rugosus** was common in dry upland pastures where it was associated with **M. bispinosus.**

Two species of slant-headed locusts (Tryxalinae) were common. Both occurred in greatest numbers in dry upland pastures. **Syrbula admirablis** was the most common and most widely distributed. **Orphulella speciosa** was most abundant in dry upland pastures. In 1929 it slightly outnumbered **M. bispinosus** in such situations, but on account of its small size could not be rated as nearly as important.

Seasonal Occurrence of Economic Species

Grasshoppers are most numerous in late summer and early fall. Most of the species of economic importance appear as adults after the middle of July and die before October 1. Thus injury by grasshoppers is not usually conspicuous until late summer.

The bird locusts (**S. americana** and **S. damnifica**) and **Chortophaga viridifasciata** hibernate as adults. Adults of the latter species become increasingly abundant until late July or early August, and some adults persist until frost.

A few adults of the red-legged locust and the lesser migratory locust may appear during the latter part of June and they attain greatest numerical importance from the latter part of July to early September. The yellow locust begins to mature about July 20, and adults may be collected until November 1. However, it becomes relatively rare after the middle of September. **M. bispinosus** is the latest of the more important Melanopli. Adults

have been taken in July, but usually they are not collected until mid-August. They become increasingly abundant in September. In woodland pastures **Arphia xanthoptera** becomes conspicuous in late fall.

Summary

Melanoplus femur-rubrum made up over 50 per cent of the grasshopper population, and was most important in clover and alfalfa. **M. bispinosus** was the dominant species in dry upland pastures and in pastures of Bermuda grass. **M. differentialis,** although not numerically as important as a number of other species, seemed to do the most damage to succulent crops. **M. mexicanus** was relatively unimportant during the years when the collections were made. **Schistocerca americana** and **S. obscura** were very abundant and destructive locally and must be included among the species of economic importance.

Most of the destructive species of grasshoppers appear as adults after the middle of July, so that damage by grasshoppers occurs in late summer or early fall.

A NOTE ON THE HATCHING OF EGGS OF CERATOMIA UNDULOSA WLK. IN A CONSTANT TEMPERATURE INCUBATOR.

EDWIN W. HOWE, Fairfax, S. C.

A female **Ceratomia undulosa** Wlk.* (Sphingidae) captured at Wichita, Kansas, on June 4th, 1931, laid forty-four eggs in a compact mass at about 7:00 A. M. of the following day.

The eggs were subjected to an average mean temperature of 78.4 degrees F. until 9:15 P. M., June 5th; or approximately 19 hours, 15 minutes; when they were placed in a constant temperature incubator which had been adjusted to 75 degrees F.

The incubator consisted essentially of a double walled sheet-iron container with a space of one and one-half inches between the walls, this space being filled with asbestos wool for insulation; of an electrical heating unit placed about one-quarter inch below the level of the floor of the container; of an automatic thermostatic control situated in the upper part of the container; and of

*Identification by Mr. Carl Heinrich, Div. of Taxonomy of Insects, Bur. Ent., U. S. D. A.

an inner copper 'brunker' through which a brine cooling solution was run from a refrigerating unit. The refrigerating unit contained a tank with the cold unit immersed, and the brine solution consisted of NaOH at the rate of 1/8 lb., and of $CaCl_2$ at the rate of 37.5 lbs., to each ten gallons of water.

The temperature remained constant in the incubator within a range of one-half degree of 75 degrees F.

The shortest period of incubation to time of hatch of any hatched egg was 5 days, 11 hours, 45 minutes. The longest period of incubation to time of hatch of any hatched egg was 7 days, 12 hours, 57 minutes. The average period of incubation for all hatched eggs was 5 days, 22 hours, 35 minutes. These figures cover only the period of incubation in the constant temperature incubator at 75 degrees F., and are in addition to the period of approximately 19 hours, 15 minutes preceeding this period, and during which the eggs were subjected to an average mean temperature of 78.4 degrees F.

A total of 25 eggs hatched, while 19 did not hatch.

MINUTES OF THE NINTH ANNUAL MEETING OF THE KANSAS ENTOMOLOGICAL SOCIETY.

April 15, 1933. Kansas State College, Manhattan, Ks.

BUSINESS MEETING

President R. H. Painter called the meeting to order at 10:30 a. m., in room 52, Fairchild Hall.

Reports of Officers

Minutes of the eighth annual meeting were read and approved.

The secretary reported that on April 14, 1933, the Society had 134 subscriptions to Volume VI (the current volume). The subscribers are distributed in the United States, Canada, Germany, England, Italy and Peru. Report approved.

The treasurer reported that on April 14, 1933, the Society had as assets in a savings account, $321.23; in the checking account of the treasurer, $134.05; the total of bills payable was $75.64, and that all bills against the Society were paid to date. Report approved.

The editor reported that he had material enough to fill the next four issues of the Journal. A new feature of the Journal is the Department of Notes. The Journal

has increased the number of pages from 96 in Volume I, to 144 pages in Volume VI, an increase of 48 pages in the current volume over that of the first volume. In all, there have been three increases in paging of the Journal; namely, from 96 pages to 112, to 128, and to 144 in the current volume. Report approved.

The publisher, Warren Knaus, reported that he printed a few extra copies of each issue beyond the regular 225 copies.

Report of Committees:

Wild Life—W. Knaus reported that the sand dunes at Medora, Kansas, in Reno County, and on the Little Arkansas River, which are about one and a half to three miles wide and seven miles long, would make a fine preserve as a state park for plant and animal studies. The entomologists have been interested in this locality for many years. Botanists are becoming interested in the plant associations. Report approved.

Auditing Committee:

This is to certify that we have examined the records of the treasurer of the Kansas Entomological Society and have verified his report as correct. All bills, cancelled checks, subscription and reprint records have been carefully preserved and were placed before us for examination. We find that the Society has $321.23 in a savings account at the First National Bank, Manhattan, Kansas; that there is $134.05 in the checking account, that the total of bills payable is $75.64, and that all bills against the Society are paid to date.

(Signed)— R. C. Smith
R. H. Painter
Report approved.

Appointment of Committees:

Nominations Committee	**Resolutions Committee**
H. B. Hungerford, Chairman	H. R. Bryson, Chairman
Geo. A. Dean	R. H. Beamer
M. W. Allen	J. O. Nottingham
	Don B. Whelan

Auditing Committee for 1933-1934
R. C. Smith
P. A. Readio

Papers:

Three entomological papers of general interest were

read before the general session of the Kansas Academy of Science; namely:

1. Blowfly Maggot Therapy in Surgery and Medicine — Geo. A. Dean
2. Cocklebur Insects in Kansas for the Purpose of Biological Control of Xanthium in Australia — S. G. Kelly
3. Preliminary Observations on the Effectiveness of Some Moth-Proofing Chemical Compounds. — D. R. Musser

The papers as listed on page 72 of the April issue of Volume VI of the Journal were read before the Society.

Motion made and carried that the Society convene at 1:00 p. m. Motion made and carried that the Society adjourn for lunch. Adjourned at 11:50 a. m, for lunch,

Convened at 1:10 p. m.

During an intermission in the presentation of papers, Mr. D. A. Wilbur projected on the screen an illustration of pseudo-invention for collecting grasshoppers in an infested area. This illustrated just one of the ideas which are projected into the field of entomology for the control of insects.

NOTES

Dr. R. J. Tillyard. Entomologist of Australia, will arrive in Manhattan between June 14 and 18, 1933. It is planned that a field trip be taken during this time to the vicinity of Elmo, Kansas, to search for fossil Permian insects.

A letter was read from the Entomological Society of London, announcing the celebration of the centenary anniversary of the founding of that Society. President Painter had already acknowledged the requirements stipulated in the letter.

FINAL BUSINESS

Resolutions Committee:

(1) Be it Resolved: That the Kansas Entomological Society express to the officials and to the Department of Entomology at Kansas State College, to the officers of the Kansas Academy of Science, and to the Committee on Arrangements, its appreciation for the excellent facilities provided for its meeting and entertainment.

(2) Be it Further Resolved: That this Society ex-

press its appreciation to the outgoing president for his leadership and interest, to the secretary for his admirable work, to the editor of the Journal for maintaining its high quality and progressive improvement, and to Dr. Warren Knaus for his untiring efforts in printing the Journal.

(3) Be it Further Resolved: That the Society extend greeting and best wishes to the Entomological Society of London for the continued progress on this, its one hundredth anniversary.

(4) Be it Further Resolved: That due to the accidental death of Carl Cummings, the Kansas Entomological Society realizes the loss to biology, and extends its sincere sympathy to his relatives and friends.

Signed
H. R. Bryson
R. H. Beamer
Don B. Welan
J. O. Nottingham

Moved that the resolutions be adopted. Motion carried.

Membership Committee:

Since there are at present 134 subscribers to the Journal, there are 134 members, according to the minutes of the Fifth Annual Meeting of the Society (p. 95, Volume II).

Nominations Committee:

President - - -	P. A. Readio
Vice President - -	H. R. Bryson
Secretary-Treasurer -	R. L. Parker

Moved that the report of the Nominating Committee be adopted and the secretary be instructed to cast the ballot for the election of these officers. Secretary so cast the necessary ballot, electing the above named officers.

President P. A. Readio closed the meeting by asking for a motion for adjournment.

Adjourned at 4:30 p. m.

There were 55 members and friends present from Lawrence, McPherson, Baxter Springs, Wichita and Topeka, Kansas; Lincoln, Nebr.; Fayetteville, Ark., and Kansas City, Mo.

At the Club House of the Manhattan Country Club, a banquet and program were enjoyed in the evening by 58 members and friends.

R. L. PARKER, Secy.

REPRINT PRICES
JOURNAL OF THE KANSAS ENTOMOLOGICAL SOCIETY.

pp.	25 cop.	50 cop.	100 cop.	500 cop.
1— 2	$ .50	$ .75	$ 1.40	$ 6.50
3— 4	1.00	1.75	2.80	11.00
5— 8	1.40	2.80	5.60	20.00
9—12	2.00	4.00	8.00	32.00
13—16	2.50	5.00	9.00	36.00
17—20	3.00	6.00	10.00	40.00
21—24	3.50	7.00	11.00	44.00
25—28	4.00	8.00	12.00	48.00
29—32	4.50	9.00	13.00	52.00
Tables—for setting up—$1.75 per page.				
Covers	—	—	2.50	7.50

CONTENTS OF THIS NUMBER

THE GENUS XESTOCEPHALUS (HOMOPTERA, CICADELLIDAE)—HAROLD T. PETERS 73

THE AMOUNT OF SOIL BROUGHT BY INSECTS TO THE SURFACE OF A WATERED AND AN UNWATERED PLOT—HARRY R. BRYSON 81

TWO NEW SPECIES OF VESPOIDEA (HYMENOPTERA), WITH NOTES ON A PREVIOUSLY NAMED SPECIES —RAYMOND ROBERTS 91

RELATIVE IMPORTANCE OF SPECIES OF GRASSHOPPERS IN NORTHWESTERN ARKANSAS—WILLIAM R. HORSFALL, ALLEN W. DOWELL, AND CHARLES E. PALM 98

A NOTE ON THE HATCHING OF EGGS OF CERATOMIA UNDULOSA WLK. IN A CONSTANT TEMPERATURE INCUBATOR—EDWIN W. HOWE 104

MINUTES OF THE NINTH ANNUAL MEETING OF THE KANSAS ENTOMOLOGICAL SOCIETY 105

JOURNAL OF THE KANSAS ENTOMOLOGICAL SOCIETY

Publication Office, 119 South Main Street, McPherson, Kansas. W (arren) Knaus, Publisher

A quarterly journal published in January, April, July and October, devoted to Entomology in the Western Mississippi Basin and the proceedings of the Kansas Entomological Society.

Manuscripts for publication may be sent to any of the publication committee.

Subscriptions should be sent to the office of Publication, 119 South Main Street, McPherson, Kansas.

KANSAS ENTOMOLOGICAL SOCIETY

President R. H. Painter, Kansas State College, Manhattan.
Vice-President P. A. Readio, University of Kansas, Lawrence.
Sec.-Treas. R. L. Parker, Kansas State College, Manhattan.

Subscription, $1.00 per year **Single copy, 40 cents**

Volume VI, No. 3, July, 1933. **Mailed July 1st, 1933.**